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Enterolobium cyclocarpum (Jacq.) Griseb. Guanacaste, Earpod-tree

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Leguminosae Legume family

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Enterolobium cyclocarpum (Jacq.) Griseb., or guanacaste, is a huge, spreading tree (fig. 1). The bipinnate compound leaves of guanacaste have five leaflets, and seeds are contained in a curious dark-brown, curled pod (fig. 2). The tree is frequently seen in pastures and parks as well as being a common forest tree with valuable wood.

HABITAT

Native Range

Guanacaste grows in forests and savannas from central Mexico (23° N.) through Central America and northern South America (to about 7° N.), Colombia, Venezuela, Trinidad, Guyana, and extreme northern Brazil *(20, 25,* fig. 3). The species has also been widely planted as a shade tree in the Caribbean and other tropical countries.

Climate

Guanacaste colonizes a wide variety of habitats. It is a climax species in subtropical dry forest life zones and grows on disturbed areas in evergreen and semievergreen forests of the subtropical and tropical moist forest life zones *(15,25).* Dry seasons of 1 to 6 months are usual in most of the habitats of guanacaste *(3,19).* Although the species is most common at low elevations, it may be found growing naturally up to 900 m above sea level in Costa Rica *(6)* and has been planted at elevations of 1,100 m *(19).* Mean annual temperatures in the natural range of guanacaste fall in the range of 23 to 28 °C *(5, 9).* Apparently this tree has some frost resistance, for individuals

Figure 1—*Open-grown guanacaste trees in Puerto Rico.*

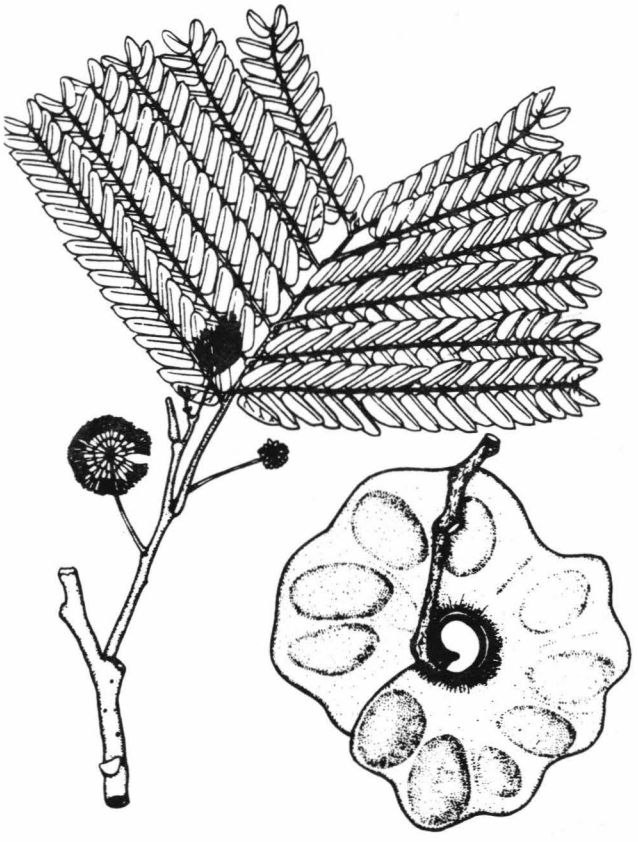

Figure 2.—*Guanacaste leaves, flowers, and fruit.*

are cultivated in Florida north of the frost line *(2).* Guanacaste is recommended for planting in areas with mean annual precipitation ranging from 750 to 2000 mm *(3, 11).* In Puerto Rico, healthy individuals are growing in areas receiving up to 2500 mm annual precipitation.

Soils and Topography

Guanacaste tolerates alkaline and calcarious soils *(3).* Ornamentals and limited plantings in Puerto Rico have grown well on soils with pH's as low as 5.0. Deep, medium-textured soils are probably best, but eroded Ultasols, deep moist clays, and shallow sandy clays over porous limestone all allow good development. Guanacaste does not seem to tolerate poorly drained soils. In wet areas, trees grow in groups on raised, better drained ground *(6).* The species is usually found on level or gently rolling topography.

Associated Forest Cover

Guanacaste is a dominant species in all the tree associations in which it is found. It is the largest tree in the tropical deciduous and semideciduous forests *(26).* In a tropical semideciduous forest in Mexico, the following important associates were recorded: *Ficus mexicana*

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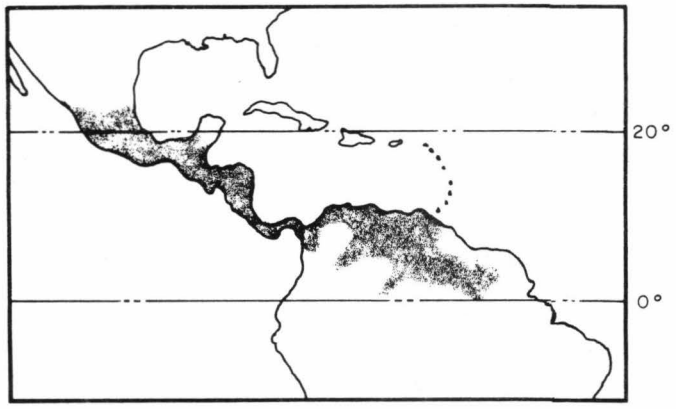

Figure 3.—*The natural range of guanacaste in Mexico and Central and South America.*

Miguelo., *F. padifolia* H.B.K., *Brosium alicastrum* Sw., *Licania arborea* Seemann, *Sideroxylon capirit* (A.DC.) Pittier, *Trichilia hirta* L., and *Bursera simaruba* (L.) Sarg. *(26).* In southern Mexico on deep soils that are now mostly cultivated, a community is described that contained (in addition to guanacaste): *Ceiba pentandra* (L.) Gaertn., *Astronium graveoleus* Jacq., *Brosimum alicastrum* Sw., *Cedrela odorata* L., *Ficus* spp., *Spondias mombin* L., and *Vitax gaumeri* Greenm *(26).* The extensive dry forest on the Pacific coast of Central America typically contains the following associates: *C. odorata* L, *Swietenia humilis* Zucc., *Samanea saman* (Jacq.) Benth., *L. arborea* Seemann, *Hymenea courbaril* L., *Andira inermis* (W. Wright) H.B.K., *Platymiscium* spp., *Chlorophora tinctoria* (L.) Gaud., *Astronium graveolens* Jacq., *Delbergia* spp., and *Sweetia panamensis* Benth. *(10).*

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Small white flowers are borne in clusters or heads at the base of leaves *(20, 25).* Flowering takes place in March and April during the regrowth of new leaves after the leafless dry season *(18, 19).* There is no indication in the literature as to at what age flowers first appear; however, trees in a 26-year-old plantation in Puerto Rico have not yet flowered. The fruits are shiny, dark-brown pods that curve around one edge giving a shape that resembles a human ear. Fruits are 7 to 12 cm in diameter and contain 8 to 16 seeds *(16, 19, 25);* they mature the year they are formed and fall in March and April. The fruits contain a syrupy pulp that makes them very attractive, and they are consumed by cows and other grazing animals in large quantities

Seed Production and Dissemination.—Seeds are easily collected by picking up the pods from the ground as they fall. Separation is accomplished by mascerating the pods or by picking out the seeds one by one with the point of a knife. One to several kilograms of seed are produced per tree. The 1.3- to 1.9-cm long seeds number about 1,100 per kilogram *(19,23).* The seeds are reported to store well *(3).* Their thickseed coats must be perforated to allow water to enter before germination can take place. This can be accomplished by nicking each seed on a grindstone or by immersing the seeds briefly in boiling water. In nature, scarification and dissemination are achieved primarily through the ingestion of the pods with their seeds by cows, horses, and wild ungulates *(19).* Rodents seem to prefer to eat germinating seeds; they hide the seeds after nicking them, which encourages germination.

Seedling Development.—Germination of guanacaste begins almost immediately after the entrance of water into the seed. Many seedlings emerge from the soil on the fourth day after planting. Germination is epigeous. One worker reported 84 percent germination *(28).* Sowing may be done in trays, beds, nursery bags, or directly in the field. Pressing the seeds into wet peat or covering them with 1 or 2 cm of moist soil is suitable. Seedlings develop rapidly, need no shade, and are quite drought hardy. Generally, good survival can be obtained with containerized seedlings and stump plantings *(3).* Seedlings should be 0.5 m high when they are ready to move to the field at 6 months. A test of containerized seedlings in southeast Mexico had an average survival of 77 percent *(4).* Although guanacaste is an often-recommended species for planting, few plantations have been established.

Natural regeneration is infrequent for several reasons. The seeds are spread principally by grazing animals, and after germination and a little height growth they are almost always eaten by the same grazing animals. They are also killed by trampling, fire, excessive shade, excessive drought, and competition from grasses *(19).* Since guanacaste is a very large-crowned tree, only an occasional survivor is necessary to achieve a striking presence in a forest or savana.

Vegetative Reproduction.—Guanacaste trees are able to coppice, and even large trees sometimes sprout when cut. Girdling to kill the trees is often ineffective because of heavy sprouting below the girdle line. The species can withstand pollarding (periodic removal of all major limbs) *(18).* There has been no report on grafting or rooting of cuttings.

Sapling and Pole Stage to Maturity

Growth and Yield.—Although guanacaste is common and has a wide range, no information is available on its growth rate in natural stands. It does have the reputation of being a fast grower. Forest-grown trees in Costa Rica reach 190 cm in d.b.h. and have clear bole lengths of 15 m *(9).* Since trees are usually widely scattered, volumes per hectare are correspondingly low.

A few trials have yielded minimal data on the species in plantations. In Costa Rica, plots 7.5 to 8 years old had heights of 11 to 16 m and d.b.h.'s of 8 to 11 cm *(6,* table 1). In southern Mexico, trees on 8-year-old plots averaged 8 m in height and 12 cm in d.b.h. *(4).* Guanacaste growing in mixture with other species on soils derived from granite averaged 6 m tall when 5 years old in Puerto Rico *(12).* At 25 years, these trees and other mixed plantings on limestone had a mean height of 18 m, a d.b.h. of 42 cm, a clear bole length of 7.4 m, and a survival of 24 percent. The tallest individual had a height of 26 m and a d.b.h. of 84 cm. As a dominant position is secured and a large crown develops, diameter growth accelerates.

Guanacaste trees are common as shade trees in pastures, parks, and large estates. In these settings guanacaste grows quite rapidly to very large sizes. Diameter increments of up to 10 cm annually have been noted *(22).* Probably the largest tree in Puerto Rico is a guanacaste

Table 1.—*Heights and diameters of guanacaste growing in research plots in three countries.*

Country and plot indentification	Age	Height	D.b.h.	Survival	Source
	Years	*m*	*cm*	*Percent*	
Mexico					
1	8.5	7.1	10.8	69	*(3)*
2	8.5	7.6	11.9	75	*(3)*
3	8.5	8.3	13.2	81	*(3)*
4	8.5	7.8	13.4	81	*(3)*
Costa Rica					
105	8.0	11.4	16.6	low	*(5)*
107	7.5	10.4	12.7	low	*(5)*
302	8.0	8.1	11.5	...	*(5)*
Puerto Rico					
SAT†	5.0	6.0	...	79	*(11)*
SAT	25	18.0	42.0	24	*

†SAT=Species' adaptability trials.

*Species' adaptability trials on granitic, and limestone soils; unpublished data on file at the Institute of Tropical Forestry, Rio Piedras, Puerto Rico.

2.4 m in d.b.h. and 39 m in height. It is between 50 and 80 years old. The tree is growing near Mayaguez with an elevation of 20 m and a rainfall of 1900 mm annually. Open-grown trees in the dry zone of Central America are reported to reach 3.0 m in d.b.h. and 40 m in height *(28)*.

Rooting Habit.—Older guanacaste trees develop small buttresses and produce large roots that run along the surface of the ground *(23)* for 2 or 3 m. Sidewalks, roads, or foundations may be cracked or raised by guanacaste trees growing close-by. A taproot is developed in seedlings, but it is not known if it persists in adult trees.

Reaction to Competition.—Guanacaste is shade intolerant as a seedling, benefiting from light shade only when stressed for moisture. It is very intolerant as an adult. The tree must receive adequate sunlight as a dominant or codominant from the sapling stage onward, or it will die. Careful weeding of plantations during the early years is essential. One 26-year-old mixed plantation in Puerto Rico had a basal area of 13 m^2/ha. Spacings of 3 by 3 m or 4 by 4 m, with thinnings on a rotation of 25 to 35 years, are recommended *(3)*. Bole length and form in plantations have been improved through the use of pruning *(6)*.

Damaging Agents.—Guanacaste does not appear to have any threatening disease or insect problems. However, root rots, butt rots, and burls often develop after mechanical or fire damage in Puerto Rico. An unnamed disease is caused by a fungus that has been identified is *Fusarium oxyosporum* var. *perniciosum (21)*. The disease results in copius yellow exudation from bark fissures on infected trunks or branches. Various wood-boring insects (buprestids, cerambicids, and scolitids) are attracted to the infected area. Eventually, weakened major limbs may fall suddenly due to their own weight, a serious hazard where trees shade houses, cars, or people. Infected trees that present a hazard should be removed as soon as the condition is noted. The limbs of guanacaste are also subject to breakage in strong winds *(20)*. A seedling disease caused by *Ravenelia lagerheimiana* Diet. has been described *(27)*. In the native range, a large number of flowers are destroyed by the gall-forming fly *Asphondylia enterolobii (19)*. A sucking insect, *Umbonia crassicorni,* attacks guanacaste in a number of locations in Costa Rica (1).

Dispite the fact that the seeds of guanacaste contain 2 percent albizzine and 1 percent pipecolic acid, a number of insects and animals still eat them *(19)*. In Costa Rica, the insect *Stator generalis* attacks the dormant seeds in the soil. The green seeds are heavily preyed on by species of *Amazona* parrots. The rodent *Liomys salvini,* when present, eats most of the available seeds on the ground. Peccaries also crack and eat the seeds *(19)*.

The sapwood of harvested guanacaste is subject to decay and insect attack, but the heartwood is resistant to decay *(19)* and perhaps dry-wood termites *(7)*. One author has reported that guanacaste is not termite resistant *(9)*.

SPECIAL USES

The greatest overall use of guanacaste is for cattle shade in pasture lands *(19, 25)*. The species is additionally useful to the stockman because cattle, horses, and goats feed heavily on the pods and, to a certain extent, on flowers and leaves *(19, 29, 30)*. Although other species are used more frequently, guanacaste is employed in Central America for coffee shade *(17)*. The species has been shown to fix nitrogen *(18)*. People eat the immature pods as a cooked vegetable and eat the seeds roasted or cooked as a legume and ground and mixed with flour *(8, 20, 23)*. The shelled seeds are reported to contain 35 percent protein *(8)*. The fruits and bark yield tannin and are used in making soap. The gum exuded from bark wounds is a substitute for gum arabic *(20)*. Extracts of the bark have been used in folk medicine to treat colds *(23)* and bronchitis *(6)*.

The sapwood of guancaste is white and sharply demarcated from the brown to reddish-brown heartwood. It has been compared with walnut in appearance *(20)*. The wood is coarse textured with an interlocking grain; it is hard and moderately durable *(7)*. Specific gravity is apparently variable, and the following values have been given: 0.4 to

0.6 *(20)* , 0.34 *(7),* and 0.37 g/cm³ (the last value was obtained from one tree sampled by the author in a medium-rainfall area in Puerto Rico). The wood dries very slowly, but with little tendency to warp or check. Shrinkage is 2.0 percent radially and 5.2 percent tangentially *(7).* The wood is easy to work with hand and machine tools, but fuzzing of the surface occurs on tension wood. The dust from dry wood is an irritant. Uses of the wood include cabinetry, furniture, paneling, veneer, construction lumber, novelty items, and kitchenware *(7,14, 20, 22, 24).* The wood is notably durable in water and has been used for water troughs and dugout canoes as well as in modern boat building *(22).* The wood is also used for posts *(19),* firewood, and to make low-quality charcoal *(3).*

GENETICS

The genus *Enterolobium* contains six or seven similar species and is confined to Mexico and Central and South America *(4).* One named variety of guanacaste is recognized, *E. cyclocarpum* v. *perota* Schombrg. *(22).* A closely related group from the Amazon region, *E. schomburgii* Benth. is currently recognized as a separate species. The chromosome number of guanacaste is 2 n = 26 *(13).*

LITERATURE CITED

1. Araya F., C.; Arguedas G., M.; Hilje Q., L.; Queros R., L.; Scorza R., F. 1980. Informe anual 1986. Cartago, Costa Rica: Programa Interinstitucional de Proteccion Forestal. 34 p.
2. Barrett, M. F. 1956. Common exotic trees of South Florida. Gainesville, FL: University of Florida Press. 414 p.
3. Bauer, J. 1982. Especies con potencial para la reforestacion en Honduras, resumenes. Tegucigalpa, Honduras: Corporacion Hondurena de Desarrollo Forestal. 42 p.
4. Bertoni, V. R.; Juarez G., V. M. 1980. Comportamiento de nueve especies forestales tropicales plantadas en 1971 en el campo experimental forestal tropical "El Tormento." Revista Ciencia Forestal. 25(5):4–39.
5. Burkart, A. 1952. Las leguminosas Argentinas, silvestres y cultivadas. Buenos Aires, Argentina: Acme Agency, Ltd. 569 p.
6. Camacho, M. P. 1981. Ensayos de adaptabilidad y rendimiento de especies forestales en Costa Rica. Cartago, Costa Rica: Instituto Tecnologico de Costa Rica y Ministerio de Agricultura y Ganaderia. 287 p.
7. Chudnoff, M. 1984. Tropical timbers of the world. Agric. Handb. 607. Washington, DC: U.S. Department of Agriculture. 466 p.
8. Espejel, I.; Martinez, E. 1979. El guanacaste. Comunicado No. 33. Jalapa, Vericruz, Mexico: Instituto Nacional de Investigaciones Sobre Recursos Botanicos. 4 p.
9. Forest Service. 1943. The forests of Costa Rica. Washington, DC: U.S. Department of Agriculture. 48 p.
10. Fournier, O., L. A. 1970. Fundamentos de Ecologia Vegetal, Segunda Parte: Sinecologia. San Jose, Costa Rica: Department of Biology, University of Costa Rica. 174 p.
11. Fournier, O., L. A.; Herrera de Fournier, M.E. 1977. La Sucesion ecologica como un metodo eficaz para la recuparacion del bosque de Costa Rica, Agronomia Costarricense. 1(1): 23–29.
12. Geary, T. F.; Briscoe, C. B. 1972. Tree species for plantations in the granitic uplands of Puerto Rico. Res. Pap. ITF-14.. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry, Southern Forest Experiment Station. 8 p.
13. Gomez, P., A. 1966. Estudios botanicos en la region de Misantla, Veracruz. Distrito Federal, Mexico: Instituto Mexicano de Recursos Naturales Renovables. 173 p.
14. Guridi, G., L. I. 1980. La madera en las artesanias del Estado de Michoacana. Boletin Divulgativo No. 50. Distrito Federal, Mexico: Instituto Nacional de Investigaciones Forestales. 128 p.
15. Holdridge, L. R. 1967. Life zone ecology. San Jose, Costa Rica: Tropical Science Center. 206 p.
16. Holdridge, L. R.; Poveda A., L. R. 1975. Arboles de Costa Rica. Vol. I. San Jose, Costa Rica: Centro Cientifico Tropical. 546 p.
17. Hueck, K. 1961. The forests of Venezuela. Fortwissenschaftliche Forschungun No. 14/6. Hamburg, Germany: Verlag Paul Parey. 106 p.
18. Hughes, C. E.; Styles, B. T. 1984. Exploration and seed collection of multiple-purpose dry zone trees in Central America. International Tree Crops Journal. 3:1–31.
19. Janzen, D. H. 1983. Costa Rican natural history. Chicago, IL: University of Chicago Press. 816 p.
20. Little, E. L.; Woodbury, R. O.; Wadsworth, F. H. 1974. Trees of Puerto Rico and the Virgin Islands, Volume 2. Agric. Handb. 449. Washington, DC: U.S. Department of Agriculture. 1024 p.
21. Martorell, Luis F. 1953. Que arbol sembrare. Caribbean Forester. 14(3/4): 152–160.
22. National Academy of Sciences. 1979. Tropical legumes: Resources for the future. Washington, DC: National Academy of Sciences. 331 p.
23. Neal, M. C. 1948. In gardens of Hawaii. Special Pub. No. 40. Honolulu, HI: Bernice P. Bishop Museum. 805 p.
24. Patino, V. F.; Villagomez, A., Y. 1976. Los analisis de semillas y su utilizacion en la propogacion de especias forestales. Boletin No. 40. Distrito Federal, Mexico: Instituto Nacional de Investigaciones Forestales. 26 p.
25. Pennington, T. D.; Sarukhan, J. 1968. Manual para la identificacion de campo de los principales arboles tropicales de Mexico. Distrito Federal, Mexico: Instituto Nacional de Investigaciones Forestales. 413 p.
26. Rzedewski, J.; Huertas M., L. 1981. Vegetacion de Mexico. Distrito Federal, Mexico: Editorial Limusa. 432 p.
27. Saenz, R., J. A.; Fournier, O., L. A. 1982. *Enterolobium cyclocarpum* (Jacq.) Gris., un nuevo hospedero para *Ravenelia lagertheimiana* Diet. Turrialba. 32(3): 333–336.
28. Salazar, R. 1985. Tecnicas de produccion de lena en fincas pequenas. Turrialba, Costa Rica: Centro Agronomico de Investigaciones y Ensenanza. 459 p.
29. Standly, P. C. 1928. Flora of the Panama Canal Zone. Contributions from the United States Herbarium Vol. 27. Washington, DC: Smithsonian Institution. 416 p.
30. Susano, H., R. 1981. Especies arboreas forestales susceptibles de aprovecharse como forraje. Revista Ciencia Forestal. 29(6): 31–39.